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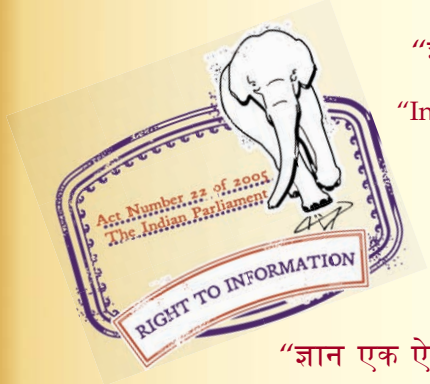

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"Knowledge is such a treasure which cannot be stolen"

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Indian Standard

SPECIFICATION FOR STANDARD REFERENCE ZERO FOR THE CALIBRATION OF PURE-TONE BONE-CONDUCTION AUDIOMETERS AND GUIDELINES FOR ITS PRACTICAL APPLICATION

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INDIAN STANDARDS INSTITUTION
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SPECIFICATION FOR STANDARD REFERENCE ZERO FOR THE CALIBRATION OF PURE-TONE BONE-CONDUCTION AUDIOMETERS AND GUIDELINES FOR ITS PRACTICAL APPLICATION

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Indian Standard

SPECIFICATION FOR STANDARD REFERENCE ZERO FOR THE CALIBRATION OF PURE-TONE BONE-CONDUCTION AUDIOMETERS AND GUIDELINES FOR ITS PRACTICAL APPLICATION

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 30 August 1984, after the draft finalized by the Acoustics Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 Standard reference zero for the scale of hearing level applicable to pure-tone air-conduction audiometers has been specified in IS : 4755-1968*. For clinical diagnostic and other audiometric purposes it is often necessary to compare the measured hearing threshold levels of a person for sound transmitted to the internal ear by the air-conduction and bone-conduction pathways respectively. Bone-conducted sound is provided for this purpose by an electromechanical vibrator applied to the mastoid process or to the forehead of the test person.

0.3 The standard reference zero for air-conduction audiometry is defined in IS : 4755-1968* in terms of reference equivalent threshold sound pressure levels (RETSPL), that is threshold sound pressure levels produced in a coupler or artificial ear of specified characteristics by supra-aural earphones of various patterns when excited electrically at a level corresponding to the threshold of hearing of young otologically normal persons (as defined in IS : 4755-1968*). Analogously, this standard provides a reference zero for bone-conduction audiometry in terms of reference equivalent threshold force levels (RETFL), that is the alternating force levels produced by a bone vibrator on a specified mechanical coupler when the vibrator is excited electrically at a level corresponding to the threshold of hearing of young otologically normal persons defined similarly to those in IS : 4755-1968*. In some countries the preferred site of placement is the mastoid prominence; in other countries the forehead site is used in addition to the mastoid prominence. Different RETFL values are valid for the two sites of vibrator placement.

*Reference zero for the calibration of pure-tone audiometers.

0.4 For bone conduction measurement it is necessary to specify the static force of application of the vibrator to the skull of the test person and to the mechanical coupler, as well as certain geometrical features of the vibrator tip. Also it is usually necessary to apply masking noise to the ear not under test, since excitation of the skull by the vibrator may be heard by that ear (especially if this is the less impaired ear) instead of (or in addition to) the intended test ear. An appropriate specification of the masking noise is, therefore, required as an adjunct to the reference equivalent threshold force levels, and such a specification is given in this standard. Due to the so-called 'occlusion effect' whereby the wearing of the transducer needed to provide the (air-conducted) masking noise causes a lowering of the bone-conduction threshold of hearing of the ear receiving the masking signal, it is necessary for the level of masking noise to be elevated to cancel out the occlusion effect and provide adequate masking of the non-test ear. The specification of masking noise given in this standard is based on the procedures used in the experimental investigations from which the reference zero of this standard is derived.

0.5 Use of this reference zero to calibrate audiometers will ensure that measured bone-conduction hearing threshold levels of persons with unimpaired hearing or with hearing losses of purely sensorineural type (that is, having unimpaired external and middle ear function) will be compatible with the air-conduction hearing threshold levels of the same persons when using the reference zero of IS : 4755-1968*. Although exact equivalence of air-conduction and bone-conduction thresholds for individuals in these classes cannot be expected, due to biological variability of sound transmission through the external and middle ear and through the skull, this standard will ensure that systematic deviations averaged over groups of such persons are reduced to a practical minimum.

0.6 This standard is based on an assessment of technical data provided by laboratories in three countries using methods of threshold testing which, in the respects described, were essentially uniform (*see* Appendix A). Examination of the data by the responsible Working Group under ISO/TC 43 of International Organization for Standardization showed that the experimental results were consistent. It has, therefore, been possible to standardize a reference zero by means of RETFL values which are independent of the pattern of bone vibrator used for the audiometry (at least for types having generally similar characteristics to those used by the laboratories); the systematic uncertainties introduced by this deliberate simplification will be small in comparison to the usual step size of hearing level controls in clinical audiometers (5 dB).

0.7 Guidance on the application of the standard reference zero to the calibration of bone-conduction audiometers is given in Appendix B.

*Reference zero for the calibration of pure-tone audiometers.

0.8 While preparing this standard, assistance has been derived from ISO/DP 7566 'Acoustics-Standard reference zero for the calibration of pure-tone bone-conduction audiometers and guidelines for its practical application' issued by the International Organization for Standardization (ISO).

0.9 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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1. SCOPE

1.1 This standard specifies the following data applicable to the calibration of bone vibrators for pure-tone bone-conduction audiometry:

a) Reference equivalent threshold force levels (RETFL), corresponding to the threshold of hearing of young otologically normal persons (*see* **2.9** and **2.10**) by bone-conduction audiometry. RETFL is the alternating force level transmitted to a mechanical coupler of specified characteristics, *see* **3.2.3**, by a vibrator when applied to the mechanical coupler under stated conditions of test and when energized at the level corresponding to the normal threshold of hearing for mastoid placement.

NOTE — Corresponding values for forehead placement of the vibrator are under development for ultimate inclusion in this standard. Provisional values are included for information in Appendix C.

b) Essential characteristics of the bone vibrator and of its method of coupling to a person under test and to the mechanical coupler.

c) Essential characteristics and datum level of the masking noise applied to the non-test ear.

2. TERMINOLOY

2.0 For the purpose of this standard, the terms and definitions given in IS : 1885 (Part 3/Sec 5)† shall apply in addition to the following.

2.1 Air Conduction — Transmission of sound through the external and middle ear to the internal ear.

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*Rules for rounding off numerical values (*revised*).

†Electrotechnical vocabulary: Part 3 Acoustics, Section 5 Speech and hearing.

2.2 Acoustic Coupler — A cavity of specified shape and volume, specified in IS : 10779* which is used for the calibration of a supra-aural earphone in conjunction with a calibrated microphone to measure the sound pressure developed within the cavity.

2.3 Artificial Ear — A device, specified in Indian Standard specification for an artificial ear of the wide-band type for the calibration of earphones used in audiometry (under preparation), for the calibration of an earphone which presents to the earphone an acoustic impedance equivalent to the impedance presented by the average human ear. It is equipped with a calibrated microphone for the measurement of the sound pressure developed by the earphone.

2.4 Bone Conduction — Transmission of sound to the internal ear mediated primarily by mechanical vibration of the cranial bones.

2.5 Bone Vibrator — An electromechanical transducer intended to produce the sensation of hearing by vibrating the cranial bones.

2.6 Alternating Force Level (Force Level) — The alternating force level of a vibration, in decibels, is 20 times the logarithm to the base 10 of the ratio of the rms value of the force transmitting the vibration to the reference value, 1 μN.

2.7 Mechanical Coupler — A device, designed to present a specified mechanical impedance to a vibrator applied with a specified static force, and equipped with a mechano-electric transducer to enable the alternating force level at the surface of contact between vibrator and mechanical coupler to be determined.

2.8 Threshold of Hearing — The level of a sound or vibration at which, under specified conditions, a person gives 50 percent of correct detection responses on repeated trials.

2.9 Otologically Normal Person — A person in a normal state of health who is free from all signs or symptoms of ear disease and from obstructing wax in the ear canal, and who has no history of undue exposure to noise.

2.10 Reference Equivalent Threshold Force (Or Reference Equivalent Threshold Sound Pressure) Level — At a specified frequency, a statistic of central tendency derived from an adequately large number of ears of otologically normal persons of both sexes aged between 18 and 30 years inclusive, expressing the threshold of hearing in a specified mechanical coupler (or acoustic coupler or artificial ear) for a specified type of transducer as applicable.

*Provisional reference coupler for the calibration of earphones used in audiometry.

NOTE 1 — For the present International Standard the mean statistic has been adopted. The air-conduction threshold specified in IS : 4755-1968* is based on modal values.

NOTE 2 — The relation between hearing threshold levels (for air conduction) and age is specified in Indian Standard specification on threshold of hearing by air conduction as a function of age and sex for otologically normal persons (*under preparation*).

2.11 Hearing Level of a pure tone at a specified frequency, for a specific type of transducer and for a specified manner of application. The alternating force level (or the sound pressure level) of this pure tone produced by the transducer in a specified mechanical coupler (or acoustic coupler or artificial ear) minus the appropriate reference equivalent threshold force level (or reference equivalent sound pressure level) for bone or air conduction as applicable.

NOTE — By extension this definition may be applied to a narrow band of noise.

2.12 Hearing Threshold Level of a given ear for a specified frequency and for a specified type of transducer. The threshold of hearing at that frequency expressed as hearing level.

2.13 Occlusion Effect — The lowering of the hearing threshold level of a given ear stimulated by bone conduction when an earphone or earplug is placed over or in the entrance to the ear canal, thereby forming an enclosed air volume in the external ear. The effect is greatest at low frequencies.

2.14 Masking

2.14.1 The process by which the threshold of hearing of a sound is raised by the presence of another (masking) sound.

2.14.2 The amount by which the hearing threshold level is so raised, expressed in decible.

2.15 Datum Level of Masking Noise — The level, expressed as hearing level (*see* Note under **2.11**) of a 1/3-octave band of noise delivered by air conduction in the presence of which a pure tone at the centre frequency of the noise band and at a hearing level of 35 dB is just audible on the basis of 50 percent detection in repeated trials by an otologically normal person having zero hearing threshold level by air conduction for that pure tone.

NOTE — The value 35 dB has been adopted arbitrarily as lying within the range used in experimental studies on which this standard is based. It does not imply a recommendation to adopt this level of masking noise in clinical practice.

*Reference zero for the calibration of pure-tone audiometers.

2.16 Auditory Critical Band — The widest frequency band within which the loudness of a band of continuously-distributed random noise of constant band sound pressure level is independent of its bandwidth.

2.17 Vibrotactile Threshold Level — The level of an alternating force at which a person gives 50 percent of correct detection responses on repeated trials due to the sensation of vibration on the skin.

3. SPECIFICATION

3.1 Reference equivalent threshold force levels are given in Table 1. They are derived from determinations of the threshold of hearing by bone conduction of otologically normal persons in conditions corresponding to **3.2.1** to **3.2.8** below.

TABLE 1 REFERENCE EQUIVALENT THRESHOLD FORCE LEVELS FOR MASTOID PLACEMENT OF VIBRATOR (ROUNDED TO NEAREST 0·5 dB)

FREQUENCY Hz	RETFL (ref 1 μN) dB
250	67·0
315*	64·0
400*	61·0
500	58·0
630*	52·5
750	48·5†
800*	47·0
1 000	42·5
1 250*	39·0
1 500	36·5†
1 600*	35·5
2 000	31·0
2 500*	29·5
3 000	30·0
3 150*	31·0
4 000	35·5
5 000	40·0†
6 000	40·0†
6 300	40·0†
8 000	40·0†

*Valves for these frequencies are interpolated.
†Values for these frequencies are derived from the results in one country only.

NOTE — Values for frequencies below 250 Hz are not specified in this standard. Results from one laboratory are given for information in Appendix D.

3.2 The applicable conditions are as follows.

3.2.1 *Bone Vibrator* — The vibrator has a plane circular tip of nominal area 175 mm^2. Any airborne sound which it radiates when in contact with the head of a test person having unimpaired external and middle ear function is low enough in level to provide a margin of 10 dB or better between the true bone-conduction hearing threshold level and a false air-conduction hearing threshold level evoked by the bone vibrator.

NOTE — If this condition is not met directly at all frequencies the unwanted sound radiation is excluded by inserting an ear plug into the external canal of the test ear at the frequencies which are affected. Use of the ear plug is confined to frequencies above 2 000 Hz.

3.2.2 *Fitting of the Bone Vibrator* — A headband is used to hold the vibrator on the mastoid with a static force of 5·4 N. The vibrator is placed on the mastoid prominence, not touching the pinna, and adjusted so as to remain in a stable position.

3.2.3 *Mechanical Coupler* — The Mechanical Coupler complies with the Indian Standard specification on mechanical coupler for the calibration of bone vibrator (*under preparation*).

3.2.4 *Test Signal* — The alternating force signal produced by the bone vibrator at the excitation level corresponding to Table 1, as measured on the mechanical coupler, exhibits total harmonic distortion not exceeding 1 percent for fundamental frequencies of 500 Hz to 1 000 Hz, and 2 percent for frequencies from 250 Hz to 400 Hz inclusive and from 1 250 Hz upwards.

3.2.5 *Masking Noise* — The masking noise signal is generated by passing random white noise, defined as having constant mean square sound pressure in Pa^2 per unit bandwidth in Hz, through a band-pass filter 1/3-octave wide centred logarithmically on the test-tone frequencies given in Table 1.

3.2.6 *Masking Transducer* — The masking noise signal is delivered to the non-test ear by means of a supra-sural earphone of a pattern conforming to one of the specifications in IS : 4755-1968*.

3.2.7 *Fitting of Masking Transducer* — The earphone delivering the masking noise is applied to the non-test ear of the test person by means of a headband exerting a force of 4·5 ± 0·5 N, and designed not to interfere with the headband holding the bone vibrator which is worn simultaneously.

*Reference zero for the calibration of pure-tone audiometers.

3.2.8 *Datum Level of Masking Noise* — The masking noise, applicable to the mean otologically normal young person as defined in **2.9** and **2.10**, is presented at the datum level specified in **2.15**.

NOTE 1 — A constant value of 40 dB hearing level in each 1/3-octave band approximates to the datum level as defined although in principle the value depends slightly on the band centre frequency (due to the variable width of auditory critical bands). The difference between the hearing level of the noise band and that of the pure tone referred to in **2.15** (that is, 5 dB) represents the (approximate) amount by which masking noise in a critical band may exceed a pure tone at the 50 percent correct detection level of the pure tone.

NOTE 2 — The datum level may be expressed as sound pressure level in decibels relative to 20 μPa by adding 40 dB to the values of RETSPL specified in IS : 4755-1968* for the pattern of earphone used as the masking transducer.

APPENDIX A

(*Clause* 0.6)

A NOTE ON THE DERIVATION OF RETFL VALUES

A-1. SOURCE OF DATA

A-1.1 The RETFL values specified in this standard are obtained from the results of three independent experimental investigations communicated to ISO Technical Committee 43. Brief particulars of the tests are given in Table 2.

TABLE 2 INVESTIGATIONS ON RETFL VALUES

(*Clause* A-1.1)

	Investigations (*see* Note)		
	A	*B*	*C*
Type of vibrator	B71*	B71	KH-70†
Type of masking earphone	TDH 39‡	TDH 39‡	DT 48§
Level of masking noise	30 dB effective‖	25 dB & 40 dB sensation level	40 dB effective‖ at 125 Hz, 250 Hz, 30 dB effective‖ at higher frequencies
No. of ears tested	60	136	50
No. of subjects	60	68	25
Frequencies tested (Hz)	250, 500, 1 000, 2 000, 3 000, 4 000,	250, 500, 1 000, 2 000, 3 000, 4 000,	125, 250, 500, 750, 1 000, 1 500, 2 000, 3 000, 4 000, 5 000, 6 000, 6 300, 8 000

Note — Refers to the following investigations:

A) Dirks (D.D.), Lybarger (S.F.), Olsen (W.O.) and Billings (B.L.). Bone conduction calibration — present status. J. Speech Hearing Disorders 44,2; 1979; 143-155.

B) Robinson (D.W.) and Shipton (M.S.). A standard determination of paired air and bone conduction thresholds under different masking noise conditions; Audiology; 1981.

C) Richter (U.) and Brinkmann (K.). Threshold of hearing by bone-conduction — A contribution to international standardization. Scand. Audiol. 10; 1981; 235-237.

*Manufactured by Radioear Corporation, USA.
†Manufactured by VEB Pracitronic, DDR.
‡Manufactured by Telephonic Corporation, USA.
§Manufactured by Beyer AG, FRG.
‖" Effective masking level " as defined in American National Standards Institute publication S3·13 – 1972 (R 1977) appendix A4.

APPENDIX B

(*Clause* 0.7)

GUIDANCE ON THE APPLICATION OF THE STANDARD REFERENCE ZERO TO THE CALIBRATION OF BONE-CONDUCTION AUDIOMETERS

B-1. GENERAL

B-1.1 When a bone-conduction audiometer is calibrated in accordance with this standard and used under the conditions stipulated in **3** (where applicable) to measure the hearing of otologically normal subjects, a mean hearing threshold level of 0 dB should be obtained.

B-2. CHOICE AND FITTING OF BONE VIBRATOR

B-2.1 The plane circular contact area of 175 mm^2 should be met with a tolerance of $\pm$ 25 mm^2, as specified in IS : 10565-1983*. The addition of a slightly rounded edge for example, radius 0·5 mm, to the vibrator tip prevents discomfort. In general the inertia-reaction types of vibrator descended from hearing aid designs have only limited output for acceptable distortion at low frequencies, and are not usually suitable for audiometry below 250 Hz; the larger button-type vibrators tend to be superior in this respect but may produce more unwanted sound radiation at high frequencies due to their larger size.

B-2.2 The headband used should provide the nominal static force of 5·4 N within a tolerance of $\pm$ 0·5 N.

NOTE — A headband providing a force of 5·4 N for a mean head width of 145 mm (for mastoid application) or 190 mm (for forehead application) will usually comply within the above tolerance for adult test populations.

B-3. CALIBRATION OF THE BONE VIBRATOR

B-3.1 The vibrator should be attached to the mechanical coupler with a static force of 5·4 $\pm$ 0·5 N, as specified in IS : 10565-1983*. The bone vibrator and mechanical coupler should both be brought to the proper operating temperature (usually 23°C) and any deviation should be allowed for, using the manufacturer's data for temperature dependence of the sensitivity of the mechanical coupler.

B-4. CHOICE AND FITTING OF MASKING TRANSDUCER

B-4.1 It is convenient to use the same earphone for delivering the masking noise as is used to determine the subject's air-conduction threshold in the

*Specification for diagnostic audiometers.

non-test ear. The nominal headband force of 4·5 N should be met within a tolerance of ± 0·5 N. These procedures enable the hearing level of the masking noise to be set correctly using the pure-tone air-conduction calibration of the earphone according to IS : 4755-1968*.

B-5. MASKING NOISE SOURCE

B-5.1 The datum conditions of this standard specify noise with a 1/3-octave bandwidth derived from random noise having uniform spectral density (white noise). Tolerance on the bandwidth (defined by the 4 dB-down points of the spectral density) of + 1/6, − 0 octave is recommended. For generating 1/3-octave band masking noise from wide-band white noise, the filter characteristics should conform to the specifications IS : 6964-1973† but excluding response shapes which lead to an effective bandwidth less than 1/3-octave. (*See also* Appendix E.)

APPENDIX C

(*Clause* 1.1)

INTERIM PROPOSAL FOR REFERENCE EQUIVALENT THRESHOLD FORCE LEVELS FOR FOREHEAD PLACEMENT OF VIBRATOR

Interim reference equivalent threshold force levels for forehead placement of vibrator are given in Table 3. They are derived from determinations of the threshold of hearing by bone conduction on otologically normal persons in conditions corresponding to the relevant specifications as specified in **3.2.1** to **3.2.8.**

*Reference zero for the calibration of pure-tone audiometers.

†Octave, half-octave and third-octave band filters for analysis of sound and vibrations.

TABLE 3 INTERIM EQUIVALENT THRESHOLD FORCE LEVELS FOR FOREHEAD PLACEMENT OF VIBRATOR (ROUNDED TO NEAREST 0·5 dB)

FREQUENCY Hz	RETFL (ref 1 μN) dB
250	79·0
315*	76·5
400*	74·5
500	72·0
630*	66·0
750	61·5†
800*	59·0
1 000	51·0
1 250*	49·0†
1 500	47·5†
1 600*	46·5
2 000	42·5
2 500*	41·5
3 000	42·0
3 150*	42·5
4 000	43·5
5 000	51·0†
6 000	51·0†
6 300	50·0†
8 000	50·0†

NOTE — The RETFL values given above are obtained from the results of four experimental investigations communicated to ISO Technical Committee 43. Brief particulars of these tests are given in Table 4.

*Values for these frequencies are interpolated.
†Values for these frequencies are derived from the results in one country only.

TABLE 4 INVESTIGATIONS OF RETFL VALUES

	Investigation (*see* Note)			
	A	*B*	C_1	C_2
Type of vibrator	B 71	B 71	KH 70	B 71
No. of ears tested	26	30	50	50
No. of subjects	26	30	25	25
Frequencies tested, Hz	250, 500, 1 000, 2 000, 3 000, 4 000*	250, 500, 1 000, 2 000, 3 000, 4 000	125, 250, 500, 750, 1 000, 1 500, 2 000, 3 000, 4 000, 5 000, 6 000, 6 300, 8 000	250, 500, 750, 1 000, 1 500, 2 000, 3 000, 4 000

Note — Refers to the following investigations:

A) Frank (T.). Clinical note: Forehead vs mastoid threshold differences with a circular tipped vibrator. Communication Disorders Program. 1981. Pensylvania State University.

B) Haughton (P.M.) and Pardol (K.). Normal pure tone thresholds for hearing by bone conduction. Brit. Journ. Audiol. 15; 1981; 113-121.

C_1) Richter (U.) and Brinkmann (K.). Threshold of hearing by bone-conduction — a contribution to international standardization. Scan. Audiol. 1981.

C_2) Richter (U.) and Brinkmann (K.). Personal communication to ISO/TC 43. 1981.

*The result at 4 000 Hz was not take into account because airborne sound radiation of the bone vibrator had not been considered.

APPENDIX D

(*Clause* 3.1)

BONE CONDUCTION THRESHOLD FOR FREQUENCIES BELOW 250 Hz

Bone conduction threshold measurements at frequencies below 250 Hz are only of limited use, partly because of the high signal distortion of present inertia-reaction types of bone vibrators (*see* **B-2**) and partly because of a possible misinterpretation of test results on

subjects with hearing loss due to vibrotactile sensation. However, reference equivalent threshold force levels for frequencies from 125 Hz to 200 Hz were determined (*see* Appendix A) and are given for information in Table 5 both for mastoid and for forehead placement of the bone vibrator. They are derived from a determination of the threshold of hearing by bone conduction of otologically normal persons under conditions corresponding to paragraphs **3.2.1** to **3.2.3** and **3.2.5** to **3.2.8**. The total harmonic distortion of the test signal used did not exceed 2 percent as measured according to **3.2.4**.

TABLE 5 REFERENCE EQUIVALENT THRESHOLD FORCE LEVELS (ROUNDED TO THE NEAREST 0·5 dB)

Frequency Hz	RETFL (ref 1 μN)	
	Mastoid Placement of Vibrator	Forehead Placement of Vibrator
	dB	dB
125	82·5	89·5
160*	77·5	86·0
200*	72·5	83·0

*Values for these frequencies are interpolated.

APPENDIX E

(*Clause* B-5.1)

AUDITORY CRITICAL BANDWIDTHS* AND CORRECTIONS FOR 1/3-OCTAVE BANDS

CENTRE FREQUENCY Hz	CRITICAL BANDWIDTH		BANDWIDTH CORRECTION FOR 1/3-OCTAVES† dB
	Hz	Octave	
125	100	1·13†	0
160	100	0·89†	0
200	100	0·71†	0
250	100	0·57†	0
315	103	0·47†	0
400	106	0·38†	0
500	115	0·33	0·0
630	125	0·29	0·7
750	137	0·26	1·0
800	140	0·25	1·2
1 000	160	0·23	1·6
1 250	190	0·22	1·8
1 500	225	0·22	1·9
1 600	240	0·22	1·9
2 000	290	0·21	2·0
2 500	380	0·22	1·8
3 000	470	0·23	1·6
3 150	500	0·23	1·6
4 000	670	0·24	1·4
5 000	900	0·26	1·1
6 000	1 100	0·26	1·0
6 300	1 200	0·27	0·8
8 000	1 600	0·29	0·6

*Values taken from experimental results using the loudness criterion to determine critical bandwidth (*see* **2.16**).

†The correction is zero when the critical bandwidth exceeds the noise bandwidth (1/3-octave).

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	Unit	Symbol
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	Unit	Symbol	Definition
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2